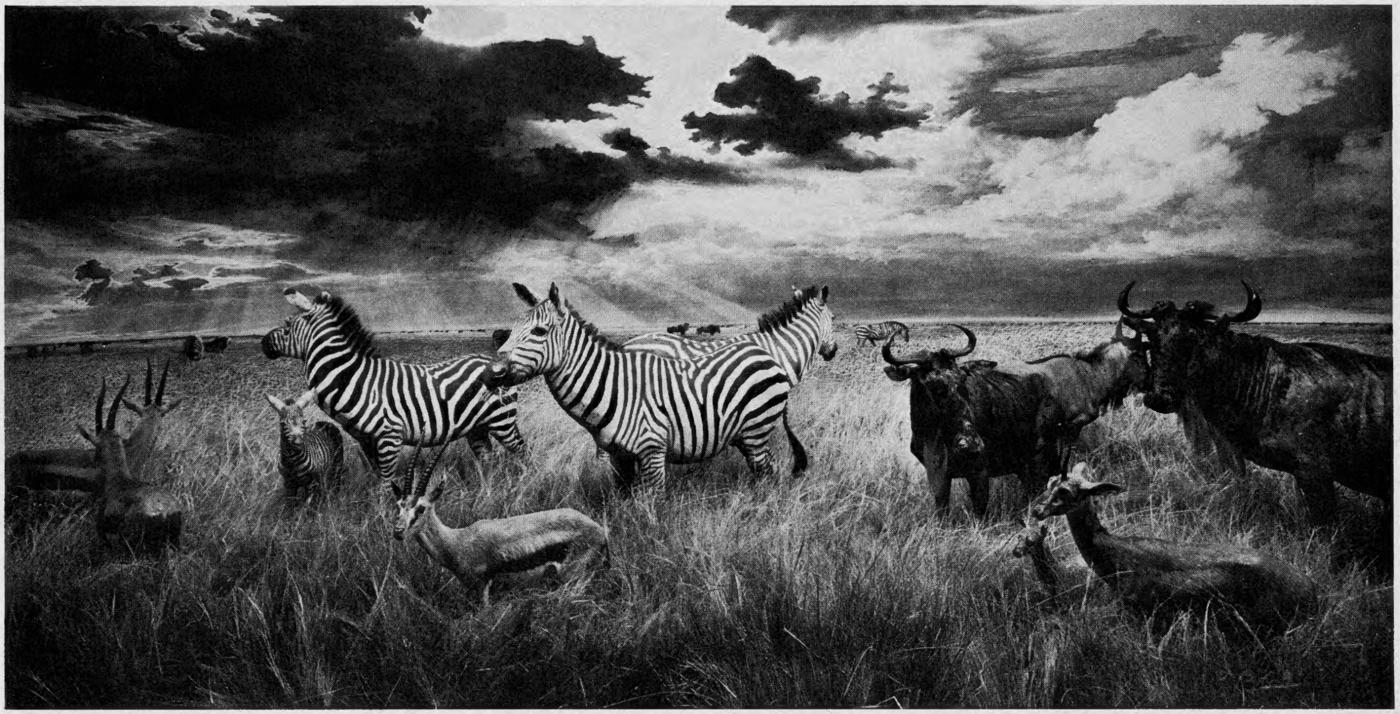
Keys to Identification of The Orders and Families of Living Mammals of the World



By George F. Fisler
Department of Biology
San Fernando Valley State College
Northridge, California 91324
and
Research Associate
Los Angeles County Museum of Natural History

Science Series 25, Zoology No. 12

Keys to Identification of The Orders and Families of Living Mammals of the World

By George F. Fisler
Department of Biology
San Fernando Valley State College
Northridge, California 91324
and
Research Associate
Los Angeles County Museum of Natural History

Science Series 25, Zoology No. 12
September, 1970

The species identification of mammal specimens can be a difficult undertaking for the interested, but untrained, person. Field guides are useful, of course, but to successfully use most one should already know the families of mammals. A way to help solve this problem may be to provide simplified keys which would enable an interested person to identify orders and families. This handbook, then, is an attempt to provide a stepping stone to species identification to anyone with an interest in mammals. With some patience and a willingness to learn a few terms which describe mammalian characteristics, these keys can be used not only to identify orders and families, but also to learn characteristics which distinguish these mammalian groups. From there, one can proceed to species identification through use of field guides or other literature designed for such use.

Furthermore, I have found that the same problem arises in teaching a mammalogy course with a world wide taxonomic coverage. A major stumbling block in laboratory instruction has been the inability of beginning students to determine quickly the order and family to which a particular specimen belonged. Essentially they would have to be told and only then could they proceed to learn the characteristics involved. It is, to me, more exciting to be able to discover for oneself the familial identity of exotic, as well as native, specimens. These keys, then, are an outgrowth of my desire to have a set of keys to *all* orders and families of living mammals available as an identification and learning tool. They are not intended for the experienced systematic mammalogist. He will know already the orders and most of the families. Presumably these simplified keys will be useful to beginning and intermediate mammalogy students as well as to interested amateurs. Should they be useful at other levels, I would be doubly gratified.

The keys are dichotomous throughout. This means that the user must select one of two possible pathways (a or b) at each numbered couplet. The number at the end of his choice pathway will direct him to the next applicable couplet, or else there will be a name at the end of the selected pathway which will be the correct, if all choices made have been correct, ordinal or familial identification of the specimen in hand. In constructing keys as broad as these, there will be inevitable mistakes and omissions. I find that construction of such keys is rather like putting together a jigsaw puzzle, except here there are extra pieces which do not fit anywhere. Not all specimens will "key down" because not all specimens will contain the "key" characters, or at least will have them only in a modified form. The student may be forced, in some cases, to follow both choices in a couplet and exercise some judgment as to where the specimen best fits. Hopefully, this type of problem is minimal. Problems that do arise, however, should be noted and drawn to the attention of the author. I hope that the keys may be improved over time.

Certain areas of weakness in the keys are known. It is almost mandatory that a specimen include both skin and skull for identification. In practice this is frequently not feasible, particularly in such orders as the Cetacea, Pinnipedia, Proboscidea, Sirenia, Perissodactyla, and Artiodactyla. It is also true for other orders which include some fairly large species (Marsupialia, Primates, Carnivora). Whenever this occurs, I have attempted to include at least one skull character in every couplet, but unfortunately this could not be done universally. Indeed, the very first couplet in the ordinal key does not contain a skull character. However, in cases such as this, there should be little difficulty in making a choice when characters are related to succeeding couplets. Also, dentition (both number and form of teeth) plays an important part in familial identification. This character, and other skull characters, frequently change as the juvenile grows to adulthood making it extremely difficult for the inexperienced to equate some forms. These keys are designed for the identification of adult specimens only. Certain juveniles and subadults may key

down correctly, but the fallibility of the keys for non-adult specimens is great. Also, there are certain genera which will not key down readily because they do not contain adequate "key" characters, or at least I have not found them. But this problem, I think, is minimal.

Some knowledge of mammalian skin and skull characters is necessary in order to successfully key down specimens in these keys. With a little experience, and some familiarity with the keys, identification should be relatively simple. It should be pointed out that characters joined by "and" in the keys should be taken in common, whereas those joined by *"or"* indicate that some specimens have one character, others the second character. Usually, the first character listed is the most reliable. Also, since the inexperienced user will frequently be dealing with many new terms, a glossary identifying these as used in the keys is provided. Twenty illustrations are also included. Further useful definitions of skin and skull measurements and skull parts may be found in Cockrum (1962a; 1962b). A hand lens or dissecting microscope is useful at times, particularly as an aid in counting the number of teeth in small specimens. Publications listed in the reference section of this handbook will provide considerable mammalian information and will also lead to additional literature.

In construction of the keys, I have personally keyed down specimens representing 720 of the approximately 1,000 mammalian genera. No list of species keyed was made, but the number of species checked is considerably in excess of the generic number. Of the 123 families recognized in these keys, representatives of 120 have been examined and keyed. Representatives of all 19 orders have been seen. A list of the orders and families, with common names, has been included for quick reference. The classification employed is primarily that of Simpson (1945).

ACKNOWLEDGMENTS

I am indebted to the former and present curators of mammals, Charles A. McLaughlin and Donald R. Patten, respectively, of the Los Angeles County Museum of Natural History for permission to use the collections under their care. Richard G. Van Gelder, chairman, Department of Mammalogy, American Museum of Natural History, New York, kindly allowed me unlimited use of the extensive collections under his care. Andrew Starrett, San Fernando Valley State College, has provided numerous helpful comments on the entire manuscript. Donald R. Patten has also offered useful suggestions. Lan A. Lester, Los Angeles County Museum of Natural History, has been extremely helpful in ways too numerous to list. Furthermore, I am indebted to the many students who have used and constructively criticized these keys. Many improvements have resulted from these comments.

The illustrations for these keys have been prepared by Mary Butler and Evie Templeton of the Los Angeles County Museum of Natural History staff. Their efforts and understanding have resulted in the excellent drawings for which I am very grateful.

LIST OF COMMON AND SCIENTIFIC NAMES OF THE ORDERS AND FAMILIES OF LIVING MAMMALS

Monotremata: monotremes or egg-laying mammals
- Tachyglossidae: spiny anteaters or echidnas
- Ornithorhynchidae: duckbilled platypus

Marsupialia: marsupials or pouched mammals
- Didelphidae: American opossums
- Dasyuridae: marsupial rats, mice, cats, Tasmanian devil and wolf
- Myrmecobiidae: marsupial anteater
- Notoryctidae: marsupial mole
- Peramelidae: bandicoots
- Caenolestidae: mouse opossums
- Phalangeridae: phalangers, possums, cuscuses, koala
- Phascolomidae: wombats
- Macropodidae: kangaroos, wallabies

Insectivora: insectivores
- Solenodontidae: solenodons
- Tenrecidae: tenrecs
- Potamogalidae: otter-shrews
- Chrysochloridae: golden moles
- Erinaceidae: hedgehogs
- Macroscelididae: elephant shrews
- Soricidae: shrews
- Talpidae: shrew-moles, moles

Dermoptera
- Cynocephalidae: flying lemurs

Chiroptera: bats
- Pteropidae: fruit-eating bats
- Rhinopomidae: mouse-tailed bats
- Emballonuridae: sheath-tailed bats, sac-winged bats
- Noctilionidae: bulldog bats
- Nycteridae: slit-faced bats
- Megadermidae: large-winged bats
- Rhinolophidae: horseshoe-nosed bats
- Hipposideridae: Old World leaf-nosed bats
- Phyllostomatidae: American leaf-nosed bats
- Desmodontidae: vampire bats
- Natalidae: funnel-eared bats
- Furipteridae: smoky bats
- Thyropteridae: disc-winged bats
- Myzopodidae: sucker-footed bat
- Vespertilionidae: common bats

Chiroptera *(continued)*
- Mystacinidae: New Zealand short-tailed bat
- Molossidae: free-tailed bats

Primates: primates
- Tupaiidae: tree shrews
- Lemuridae: lemurs
- Indridae: woolly lemurs
- Daubentoniidae: aye-ayes
- Lorisidae: lorises, pottos, galagos
- Tarsiidae: tarsiers
- Cebidae: New World monkeys
- Callithricidae: marmosets
- Cercopithecidae: Old World monkeys
- Pongidae: gibbons, orangutan, chimpanzee, gorilla
- Hominidae: man

Edentata: sloths, anteaters, armadillos
- Myrmecophagidae: anteaters
- Bradypodidae: tree sloths
- Dasypodidae: armadillos

Pholidota
- Manidae: pangolins

Lagomorpha: pikas, rabbits, hares
- Ochotonidae: pikas
- Leporidae: rabbits, hares

Rodentia: rodents
- Aplodontidae: mountain beaver
- Sciuridae: squirrels
- Geomyidae: pocket gophers
- Heteromyidae: kangaroo rats, pocket mice
- Castoridae: beaver
- Anomaluridae: scaly-tailed squirrels
- Pedetidae: spring hares
- Cricetidae: voles, hamsters, gerbils, New World rats and mice
- Spalacidae: mole-rats
- Rhizomyidae: bamboo rats
- Muridae: Old World rats and mice
- Gliridae: dormice
- Platacanthomyidae: spiny dormice
- Seleviniidae: desert dormouse
- Zapodidae: birch mice, jumping mice
- Dipodidae: jerboas
- Hystricidae: Old World porcupines
- Erethizontidae: New World porcupines
- Caviidae: guinea pigs, cavies

Rodentia *(continued)*

Hydrochoeridae: capybaras
Dinomyidae: false paca
Dasyproctidae: pacas, agoutis
Chinchillidae: viscachas, chinchillas
Capromyidae: hutias
Myocastoridae: nutria
Octodontidae: octodonts or hedge rats
Ctenomyidae: tucu-tucos
Abrocomidae: chinchilla rats
Echimyidae: spiny rats
Thryonomyidae: cane rats
Petromyidae: rock rat
Bathyergidae: African mole rats
Ctenodactylidae: gundis

Cetacea: whales

Platanistidae: fresh-water dolphins
Physeteridae: sperm whale
Ziphiidae: beaked whales
Kogiidae: pygmy sperm whale
Monodontidae: white whale, narwhale
Delphinidae: dolphins, porpoises
Eschrichtiidae: gray whale
Balaenopteridae: fin-backed whales
Balaenidae: right whales

Carnivora: carnivores

Canidae: dogs, wolves, foxes, jackals
Ursidae: bears
Procyonidae: raccoons, coatis, pandas, kinkajous, ring-tailed cats
Mustelidae: weasels, skunks, minks, otters, badgers
Viverridae: civets, mongooses, genets
Hyaenidae: hyaenas
Felidae: cats

Pinnipedia: walrus, seals, sea lions

Otariidae: eared seals
Odobenidae: walrus
Phocidae: earless seals

Tubulidentata

Orycteropodidae: aardvark

Proboscidea

Elephantidae: elephants

Hyracoidea

Procaviidae: hyraxes, conies

Sirenia: dugongs, manatees

Dugongidae: dugongs, sea cows
Trichechidae: manatees

Perissodactyla: odd-toed ungulates

Equidae: horses
Tapiridae: tapirs
Rhinocerotidae: rhinoceroses

Artiodactyla: even-toed ungulates

Suidae: pigs
Tayassuidae: peccaries
Hippopotamidae: hippopotamuses
Camelidae: camels, llamas
Tragulidae: chevrotains or mouse deer
Cervidae: deer, elk, moose, caribou
Giraffidae: giraffe, okapi
Antilocapridae: pronghorn antelope
Bovidae: cattle, antelopes, gazelles, goats, sheep

1a. Body highly modified for aquatic life; fore limbs highly modified in the form of flippers or paddles 2
b. Body not highly modified for aquatic life; fore limbs not modified as flippers or paddles 4
2a. Hind limbs present externally; teeth heterodont, canines present.......... **Pinnipedia**, page 22
b. Hind limbs absent externally; dentition either absent, homodont, *or* lacking canines 3
3a. Teeth absent *or* homodont; nostrils on top of head (blowhole); nasal bones well developed *or* nasal bones reduced and skull asymmetrical.......... **Cetacea**, page 20
b. Teeth heterodont (incisors and molars, wide diastema) *or* absent; nostrils in anterior location; nasal bones rudimentary or absent; skull symmetrical... **Sirenia**, page 23
4a. Fore limbs modified as wings.......... **Chiroptera**, page 11
b. Fore limbs not modified as wings.......... 5
5a. No lacrimal bones and jugals reduced *or* absent (skull well fused, may not be an obvious character); no auditory bullae; toothless in adult; rostrum long and tubular *or* expanded as "duck bill"; epipubic bones present..... **Monotremata**, page 9
b. Not with above combination of characters.......... 6

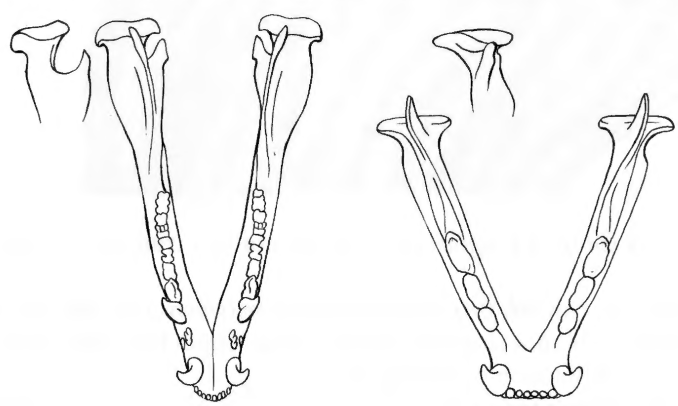


Figure 1. Dorsal views (with ventral views of angular portion of ramus) of the inflected angle of the lower jaw of *Didelphis* (a) and non-inflected angle of the lower jaw of *Lynx* (b).

6a. Well developed patagium connecting neck to fore limbs, fore to hind limbs, and hind limbs to tail; lower incisors comblike, lower canine lobate..**Dermoptera**, page 10
b. Not with above combination of characters.......... 7
7a. Skull usually with relatively small brain case and large facial region; jugal forms part of glenoid fossa; angle of jaw inflected in most species (fig. 1a); nasals large and expanded posteriorly; epipubic bones present.......... **Marsupialia**, page 9
b. Not as above; angle of jaw rarely inflected (fig. 1b).......... 8
8a. Teeth absent, *or* cheek teeth homodont and peglike in adult.......... 9
b. Teeth present, heterodont 13
9a. Teeth absent 10
b. Teeth present 11
10a. Body mostly covered by horny scales.......... **Pholidota**, page 16
b. Body not covered by horny scales.......... **Edentata** (part), page 15

11a. Body mostly covered by armor of bony skin.............................. **Edentata** (part), page 15
b. Body without armor of bony skin...12
12a. Digital formula 4-5; zygomatic arch complete; teeth without enamel and containing many tubules .... **Tubulidentata**, page 22
b. Digital formula 3-3 or less; zygomatic arch incomplete; teeth without enamel or tubules .... **Edentata** (part), page 15
13a. Digits not clearly separated; proboscis present; cheek teeth composed of transverse plates (fig. 2); one functional tooth in each half jaw....... **Proboscidea**, page 22
b. Digits clearly separated; no extensive proboscis; cheek teeth not as above......14

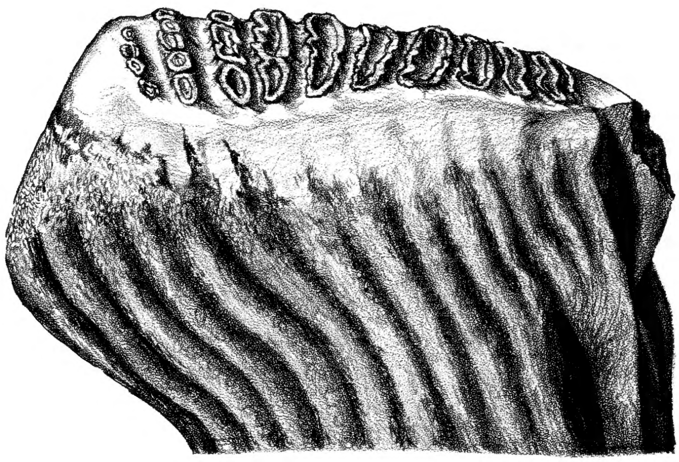


Figure 2. Cheek tooth of *Elephas* showing structure of transverse plates.

14a. Incisors 2/1 or 1/1, canines 0/0; wide diastema between incisors and cheek teeth; open orbit (orbit not ringed by bone); total length less than 1500 mm..15
b. Not with above combination of characters...16
15a. Incisors 2/1; ears longer than tail.. **Lagomorpha**, page 16
b. Incisors 1/1; ears usually shorter than tail.. **Rodentia**, page 17
16a. Digits possessing definite claws or nails...17
b. Digits not possessing definite claws or nails......................................20
17a. Digital formula 4-3, nailed (claw on first functional digit of hind foot, second actual digit); upper incisors evergrowing, enamel lacking on posterior surfaces.. **Hyracoidea**, page 22
b. Digits with claws or nails; more than 3 digits on hind foot; upper incisors not evergrowing, enameled on all surfaces (except Daubentoniidae)......................18
18a. Hallux opposable, 1 or 2 upper incisors in each half jaw, and nails on at least one digit of each foot; *or* 2 upper incisors in each half jaw and closed orbit.. **Primates**, page 13
b. Hallux not opposable; digits clawed; *or* without 2 upper incisors in each half jaw and closed orbit...19
19a. Canines enlarged over other teeth, conical, recurved, sharp-pointed, single-rooted; zygomatic arch present.. **Carnivora**, page 21
b. Upper canines as small as or smaller than largest other tooth; *or* if upper canines larger than largest other tooth, canine not round, not conical; or canine with 2 roots; zygomatic arch may be absent........................ **Insectivora**, page 10

20a. Weight supported on third digit of each foot (axis of foot through third digit, i.e.; mesaxonic); nasal bones expanded posteriorly; upper molars and premolars similar; molar surface pattern of lophs or flattened, folded loops .... **Perissodactyla**, page 23

b. Weight supported by third and fourth digits of each foot (axis of foot between third and fourth digits, i.e., paraxonic); nasal bones not expanded posteriorly; upper molars more complex than first premolars; molar surface pattern composed of cusps or crescents........ **Artiodactyla**, page 23

Key to Families of Living Monotremata

1a. Rostrum long and tapering anteriorly; body with heavy spines; tail vestigial........ **Tachyglossidae**

b. Rostrum expanded anteriorly to form "duck bill"; body without spines; tail well developed........ **Ornithorhynchidae**

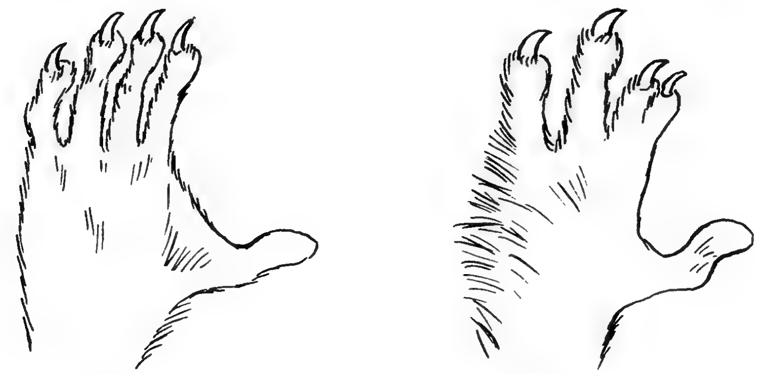


Figure 3. Unjoined digits of hind foot of *Didelphis* (a) and syndactylous hind foot of *Petaurus* (b).

Key to Families of Living Marsupialia

1a. Incisors 3/3 or more; hind foot not syndactylous (fig. 3a), except Peramelidae 2

b. Incisors less than 3/3; hind foot syndactylous (fig. 3b)........ 7

2a. Incisors 5/4; total teeth 50 in full dentition; digits 5-5........ **Didelphidae**

b. Incisors not 5/4; total teeth not 50; digits 5-5 or less........ 3

3a. Teeth well separated, evenly spaced, small, weak, may be of unequal sizes; digits 5-4; snout elongated .... **Myrmecobiidae**

b. Teeth not well separated, not small or weak; digits variable; snout usually not elongated 4

4a. Eyes vestigial, concealed beneath skin; horny shield on nose; claws of digits 3 and 4 of fore foot enlarged; molelike........ **Notoryctidae**

b. Not as above, not molelike........ 5

5a. First lower incisor enlarged, extremely procumbent and followed by 4 or 5 unicuspids; South America .... **Caenolestidae**

b. Not as above 6

6a. Hind foot syndactylous; last lower incisor bilobed........................ **Peramelidae**
b. Hind foot not syndactylous; last lower incisor usually not bilobed..... **Dasyuridae**
7a. Canines absent 8
b. Canines present 9
8a. Incisors 1/1; total teeth 24; hind foot partly syndactylous; digits 5-5 (hallux vestigial, clawless) .... **Phascolomidae**
b. Incisors 3/1; total teeth 32-34 (28 if fourth molars not erupted); hind foot syndactylous; digits 5-4.................. **Macropodidae** (mostly Macropodinae)
9a. Digits 5-5; first hind toe opposable..**Phalangeridae**
b. Digits 5-4 (except *Hypsiprymnodon* 5-5 and first hind toe not opposable)........ ....**Macropodidae** (mostly Potorinae)

Key to Families of Living Insectivora

1a. Zygomatic arch present and complete... 2
b. Zygomatic arch incomplete *or* absent... 5
2a. Auditory bullae well developed 3
b. Auditory bullae absent, or poorly developed.. 4
3a. Molelike, fossorial; digits 4-5 with central two of fore foot bearing huge claws; eyes poorly developed, covered by skin .... **Chrysochloridae**
b. Not molelike, saltatorial; digits 5-5 or 5-4; eyes well developed, not covered by skin .... **Macroscelididae**
4a. Not fossorial, front feet normal; zygomatic arch strongly developed... **Erinaceidae**
b. Fossorial, front feet usually enlarged for digging; zygomatic arch weakly developed .... **Talpidae**

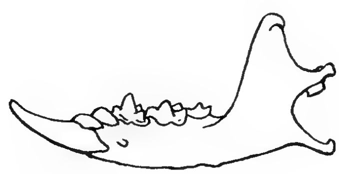


Figure 4. Procumbent first lower incisor of *Suncus.*

5a. Total teeth less than 34; first lower incisor extremely procumbent (fig. 4).......... .... **Soricidae**
b. Total teeth 36 or more; first lower incisor not procumbent, or only slightly procumbent 6
6a. First upper incisor very large, obvious gap between first and second upper incisors; skull constricted slightly between orbits; Cuba and Haiti only............... .... **Solenodontidae**
b. Not as above 7
7a. First upper and second lower incisors caniniform, canines premolariform (obviously double-rooted); otterlike .... **Potamogalidae**
b. Not as above .... **Tenrecidae**

Order Dermoptera

Family **Cynocephalidae**

Key to Families of Living Chiroptera

1a. Second digit of wing usually clawed; mandible with broad, low angular process, *or* none at all; tragus absent (fig. 5a); margin of pinna a complete ring; cochlea of ear relatively small, not constricting basioccipital...... **Pteropidae**

b. Second digit of wing never clawed; mandible with well developed, long, narrow angular process; tragus usually present (fig. 5b); margin of pinna not forming a complete ring; cochlea of ear large, frequently constricting basioccipital 2

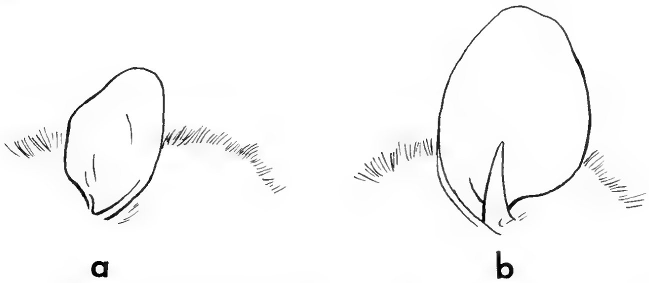


Figure 5. Ears of bats showing absence, *Epomophorus* (a), or presence, *Trachops* (b), of tragus.

2a. No premaxillaries or upper incisors; bifid tragus; ears joined by inner edges for up to one-half their length; no external tail (some phyllostomatids also tailless) .... **Megadermidae**

b. Premaxillaries and upper incisors present; tragus and ears not as above; usually with external tail........ 3

3a. Large, obvious, circular suction pads on ankles and wrists (fig. 6) 4

b. Without suction pads on ankles and wrists 5

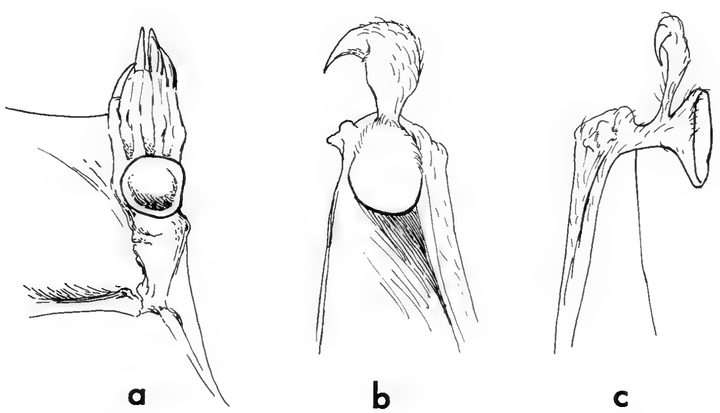
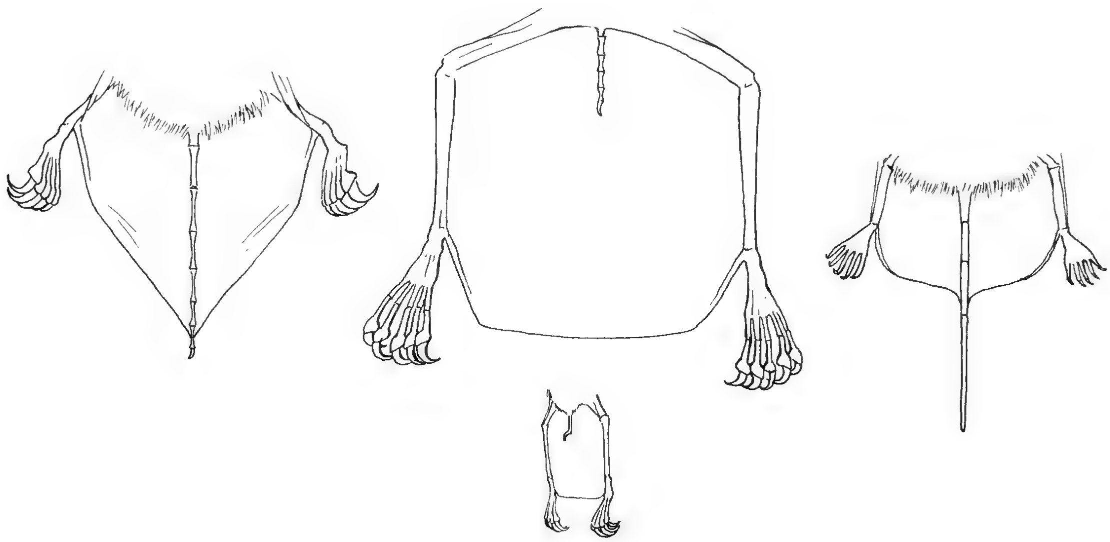


Figure 6. Suction pads on ankle (a) and wrist (b, c) of *Thyroptera.* Stalked condition of pad is also shown (c).

4a. Suction pads stalked (fig. 6c); no mushroom-shaped process in ear; New World .... **Thyropteridae**

b. Suction pads sessile; mushroom-shaped process in ear; Malagasy only........ .... **Myzopodidae**

5a. Tail mostly free of narrow interfemoral membrane, almost as long as head and body .... **Rhinopomidae**
b. Tail not mostly free of interfemoral membrane (part of tip may be free), shorter than head and body; *or* tail absent 6
6a. Tip of tail free from and lying on upper surface of interfemoral membrane (fig. 7b); *or* tail absent 7
b. Tip of tail not free (fig. 7a), *or* if free, not lying on upper surface of interfemoral membrane (fig. 7c) 11



a b c

Figure 7. Termination of tail in bats: tail enclosed in membrane, *Pizonyx* (a); tip of tail free on upper surface of membrane (two views), *Noctilio* (b); tail free, *Tadarida* (c).

7a. Postorbital processes present (fragile) .... **Emballonuridae**
b. No postorbital processes 8
8a. Total teeth 26 or less, all bladelike with no crushing surfaces .... **Desmodontidae**
b. Total teeth 28 or more 9
9a. Total teeth 30-34; *or* total teeth 28, and tailless .... **Phyllostomatidae**
b. Total teeth 28, and tailed 10
10a. Incisors 2/1; cheek teeth 4/5; New World .... **Noctilionidae**
b. Incisors 1/1; cheek teeth 5/5; New Zealand .... **Mystacinidae**
11a. Tail ending in T- or Y-shaped tip at posterior margin of interfemoral membrane .... **Nycteridae**
b. Tail not ending as above 12
12a. Tragus absent 13
b. Tragus present 14

13a. All toes, except hallux, with three phalanges .... **Rhinolophidae**
b. All toes with two phalanges .... **Hipposideridae**
14a. Total teeth 36-38 15
b. Total teeth 34 or less 17
15a. Pollex rudimentary, with minute claw, and enclosed in wing membrane .... **Furipteridae**
b. Pollex well developed, not enclosed in wing membrane 16

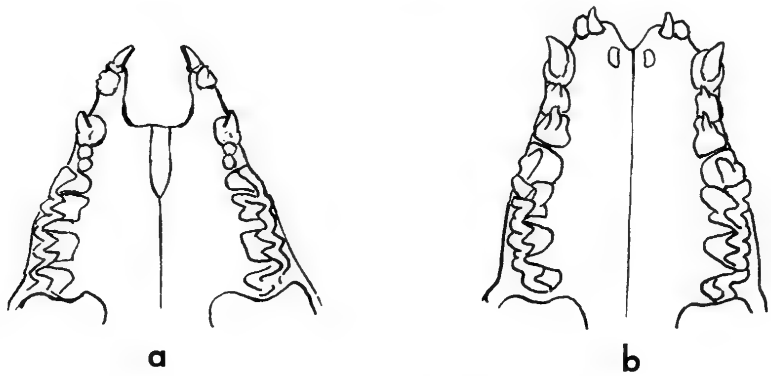


Figure 8. Premaxillary gap of *Myotis* (a) and notch at anterior end of palate of *Natalus* (b).

16a. Anterior bony palate and incisors separated at midline by a premaxillary gap (fig. 8a) .... **Vespertilionidae**
b. Anterior bony palate not separated at midline by a premaxillary gap (fig. 8b) .... **Natalidae**
17a. Hind digits 1 and 5 each with outer fringe of stiff hairs; tail extending well beyond posterior margin of interfemoral membrane (fig. 7c) .... **Molossidae**
b. Hind digits 1 and 5 without fringe of stiff hairs; tail not extending beyond posterior margin of interfemoral membrane (fig. 7a), or in a few species may extend a few millimeters 18
18a. Upper incisors separated at midline by a premaxillary gap (fig. 8a); usually no nose leaf .... **Vespertilionidae**
b. Upper incisors not separated at midline by a premaxillary gap; nose leaf obviously present, *or* rudimentary .... **Phyllostomatidae**

Key to Families of Living Primates

1a. Dental formula 2/3, 1/1, 3/3, 3/3=38; digits 5-5 and clawed .... **Tupaiidae**
b. Dental formula not as above; nails on some digits 2
2a. Dental formula 1/1, 0/0, 1/0, 3/3=18; incisors with enamel on anterior surface only; digits clawed except hallux which is nailed .... **Daubentoniidae**
b. Dental formula greater than above; incisors enameled on all surfaces; digits mostly nailed 3
3a. Upper incisors (absent in *Lepilemur*) separated at midline by space; orbital and temporal fossae confluent; face elongated 4
b. Upper incisors not separated at midline by space; orbital and temporal fossae almost or completely separated; face shortened 6
4a. Maximum number of teeth 30, upper cheek teeth five .... **Indridae**
b. Maximum number of teeth more than 30, upper cheek teeth six 5

Figure 9. Reduced second digit of front foot of *Nycticebus*.

Figure 10. Lateral opening of nostrils of platyrrhines, *Saimiri* (a), and anterior opening of nostrils of catarrhines, *Macaca* (b), as they usually appear in a prepared specimen.

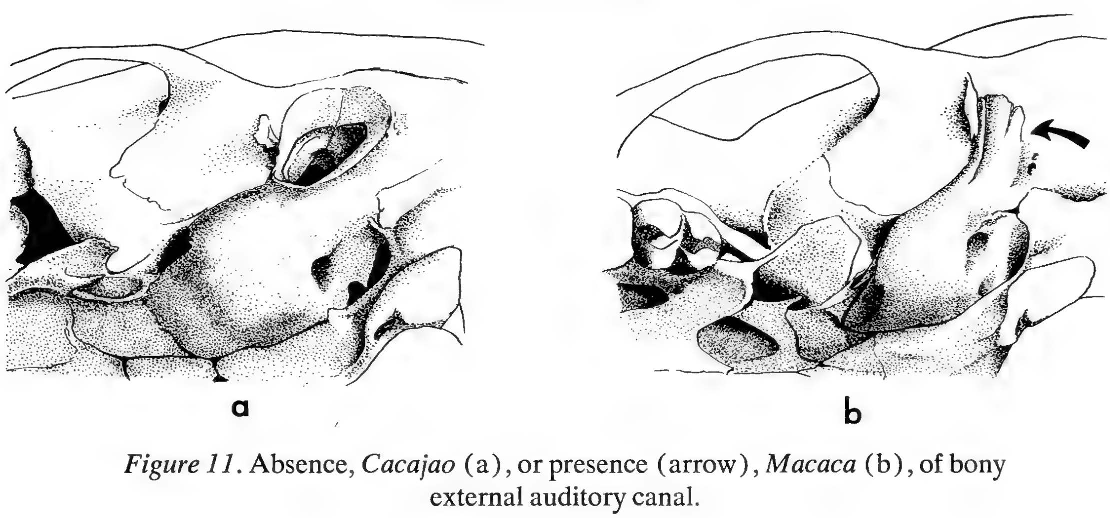


Figure 11. Absence, *Cacajao* (a), or presence (arrow), *Macaca* (b), of bony external auditory canal.

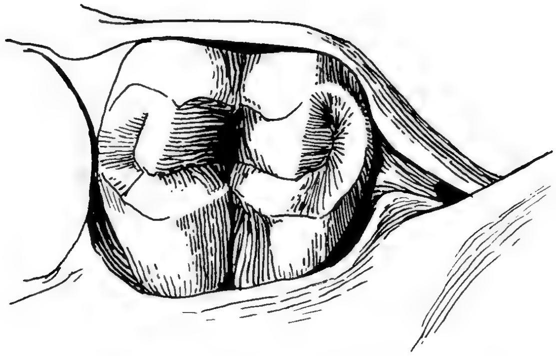


Figure 12. Transversely bilophodont molar of *Macaca.*

5a. Second digit of front foot reduced (fig. 9) *or* absent, *or* digits with flattened pads at tips; upper molars with four cusps .... **Lorisidae**
b. Second digit of front foot present and not reduced; no flattened pads at tips; upper molars essentially with three cusps .... **Lemuridae**
6a. Digits much elongated with enlarged, rounded pads at tips; orbital and temporal fossae not completely separated; incisors 2/1 .... **Tarsiidae**
b. Digits without enlarged rounded pads at tips; orbital and temporal fossae completely separated; incisors 2/2 7
7a. Nostrils open laterally, separated by wide nasal septum (fig. 10a); no bony external auditory canal (fig. 11a); no ishial callosities (Platyrrhini; Ceboidea) 8
b. Nostrils open anteriorly, separated by narrow nasal septum (fig. 10b); bony external auditory canal (fig. 11b); may have ishial callosities (Catarrhini; Cercopithecoidea and Hominoidea) 9
8a. Total teeth 36, cheek teeth six; digits with flattened or curved nails (except *Callimico,* clawed) .... **Cebidae**
b. Total teeth 32, cheek teeth five; digits clawed except hallux nailed.. **Callithricidae**
9a. With tail (absent in *Cynomacaca*); molars transversely bilophodont (fig. 12) .... **Cercopithecidae**
b. Tailless; molars not transversely bilophodont 10
10a. Cranium greatly developed and forming major portion of skull; brow ridges not prominent; mandibular symphysis not strengthened by posterior bony shelf; tooth rows form rounded arcades; hallux not opposable; canines not greatly enlarged in males, about size of adjacent teeth .... **Hominidae**
b. Cranium smaller, with face forming major portion of skull; brow ridges prominent; mandibular symphysis strengthened by posterior bony shelf; tooth rows tend to be parallel; hallux opposable; canines greatly enlarged in males, larger than adjacent teeth.......... **Pongidae**

Key to Families of Living Edentata

1a. Teeth absent; well developed tail .... **Myrmecophagidae**
b. Teeth present; tail either poorly developed and with partly fused vertebrae, *or* developed and without fused vertebrae.......... 2
2a. Armor of bony skin over much of body; zygomatic arch complete; digits at least 3-5 .... **Dasypodidae**
b. No bony armor; zygomatic arch incomplete; digits 3-3 or less .... **Bradypodidae**

Order Pholidota
Family **Manidae**

Key to Families of Living Lagomorpha

1a. Five upper cheek teeth in each half jaw; no postorbital processes on frontal bone; cutting edge of first upper incisor V-shaped; no externally visible tail; ears short, rounded; hind limbs only slightly enlarged .... **Ochotonidae**

b. Six upper cheek teeth in each half jaw (except five in *Pentalagus*); postorbital processes on frontal bone usually; cutting edge of first upper incisor straight or only shallowly V-shaped; short, visible tail; ears longer than broad; hind limbs enlarged .... **Leporidae**

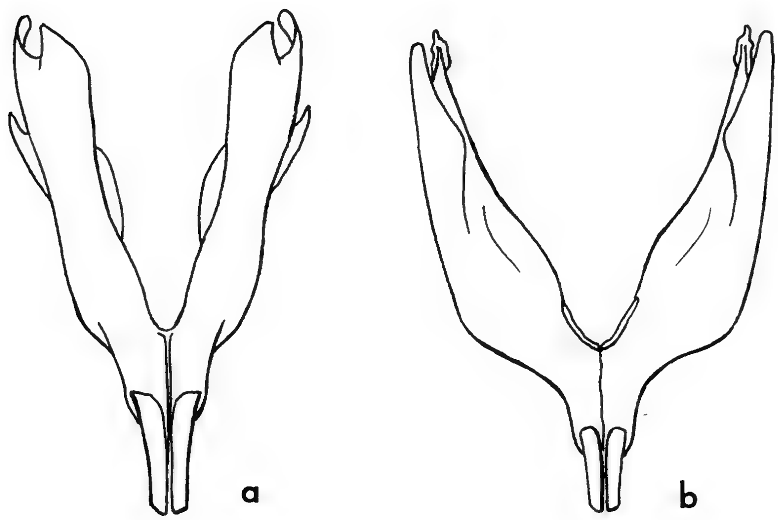


Figure 13. Sciurognath lower jaw of *Neotoma* (a) and hystricognath lower jaw of *Proechimys* (b). Note the V-shaped pattern of the jaw in the former and the Y-shaped pattern in the latter. However, in the latter, the jaw may also frequently assume a V-shape.

Figure 14. External cheek pouches of *Thomomys* as they appear in a ventral view of a prepared specimen.

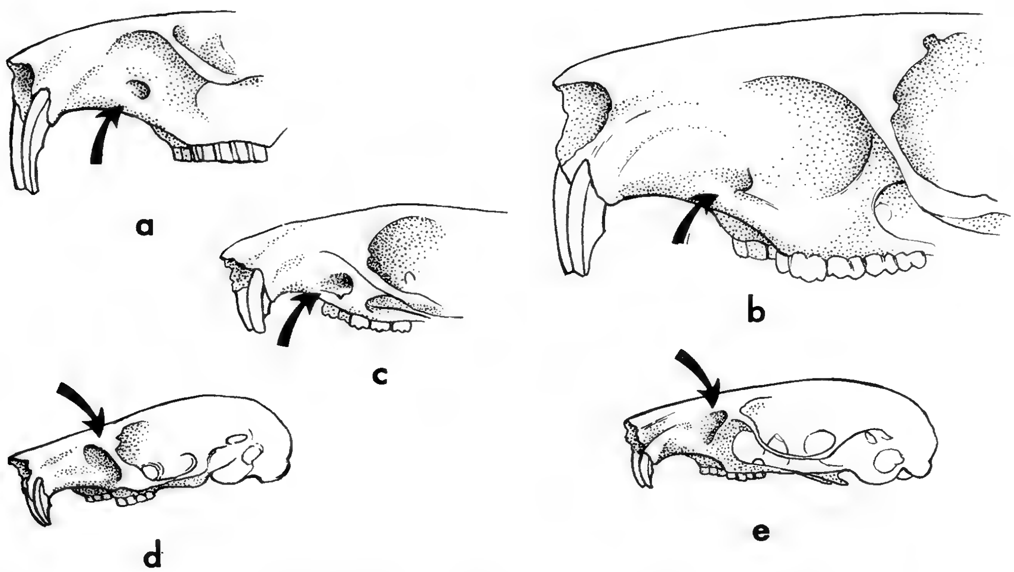


Figure 15. Appearance of infraorbital foramen: side of rostrum, *Thomomys* (a); raised area, *Sciurus* (b); hole in medial border of zygomatic plate, *Eutamias* (c); oval, *Zapus* (d); vertical slit, *Peromyscus* (e).

Key to Families of Living Rodentia

1a. Inner surface of angle of lower jaw originates behind (essentially on a straight line posterior from) or ventral to the incisor root, ventral view (fig. 13a) (sciurognath jaw) 2

b. Inner surface of angle of lower jaw originates lateral to (not on a straight line from) incisor root, ventral view (fig. 13b) (hystricognath jaw) 19

2a. Infraorbital foramen nearly as large as or larger than foramen magnum 3

b. Infraorbital foramen smaller than foramen magnum 6

3a. Digits 4-4 and not saltatorial; two inner hind digits with combs .... **Ctenodactylidae**

b. Digits other than 4-4, *or* 4-4 and saltatorial; without combs on digits 4

4a. Two rows of keeled, imbricated scales on under side of tail; gliding, fleshy membrane between fore and hind limbs (except *Zenkerella*); not saltatorial .... **Anomaluridae**

b. No distinct scales on underside of tail; no gliding membrane; saltatorial 5

5a. Total teeth 20; digits 5-4 .... **Pedetidae**

b. Total teeth 18 or less; weight of hindquarters on digits 2, 3, 4, with 1 and 5 reduced or absent .... **Dipodidae**

6a. Total teeth 20 or more 7

b. Total teeth 18 or less 12

7a. Infraorbital canal opening laterally on side of rostrum (fig. 15a), not as distinct, raised area on side of rostrum, and opening usually anterior to zygomatic plate; external, fur-lined cheek pouches present (fig. 14) 8

b. Infraorbital canal not opening laterally on side of rostrum but rather opening as a distinct, raised area, or as a hole in medial border of zygomatic plate and opening usually posterior to zygomatic plate (fig. 15b, c); no external, fur-lined cheek pouches 9

a

b

c

d

e

f

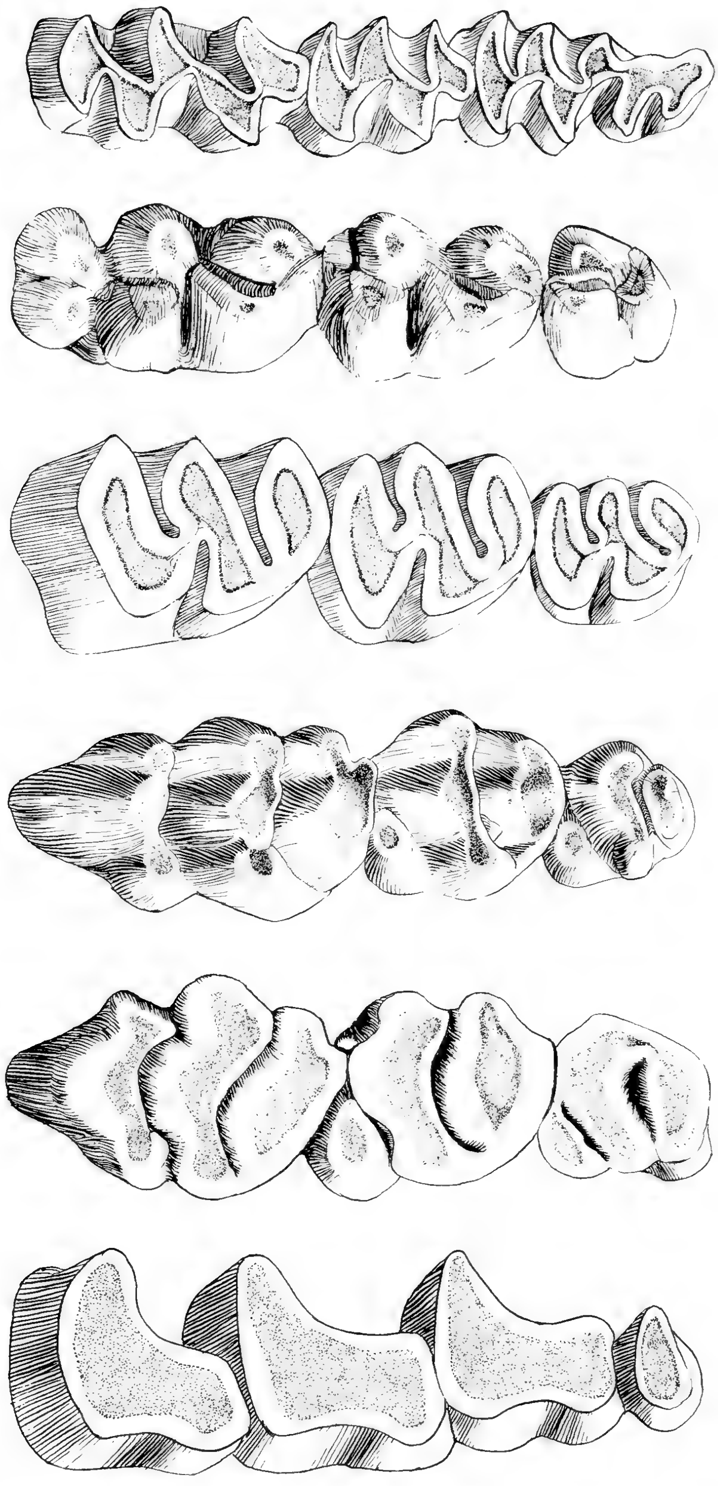


Figure 16. Crown patterns of upper molar teeth (tooth row): prismatic, *Microtus* (a); two rows of cusps, *Peromyscus* (b); laminate with wide folds, *Neotoma* (c); three rows of cusps, *Rattus* (d); chevron pattern, *Rattus* (e); octodont or kidney-shaped, *Ctenomys* (f).

8a. Digits 5-5; modified for fossorial life, massive skull, enlarged fore feet, etc.; nasal septum not perforated .... **Geomyidae**

b. Digits functionally less than 5-5 (pollex vestigial in *Liomys* and *Heteromys*); not modified for fossorial life; nasal septum perforated .... **Heteromyidae**

9a. Digits 4-5; with or without postorbital processes 10

b. Digits 5-5; no postorbital processes 11

10a. Postorbital processes present .... **Sciuridae**

b. No postorbital processes .... **Gliridae**

11a. Total teeth 20; tail dorso-ventrally flattened, scale covered; hind feet webbed; infraorbital canal slitlike, on side of rostrum .... **Castoridae**

b. Total teeth 22; tail extremely reduced, haired; hind feet not webbed; infraorbital foramen oval, in base of zygomatic arch .... **Aplodontidae**

12a. No external eye openings 13

b. External eye openings present 14

13a. No external tail; molar tooth pattern of folds .... **Spalacidae**

b. Short external tail; molar tooth pattern prismatic (similar to fig. 16a) .... **Cricetidae** (*Myospalax*)

14a. Each cheek tooth with single root; grooved upper incisors; inflated auditory bullae; known only from Kazakhstan .... **Seleviniidae**

b. Not as above 15

15a. Cheek teeth with oblique parallel ridges of enamel on crowns; very narrow zygomatic plate; base of tail scaly, scantily haired whereas remainder bears long hairs, *or* fur densely spiny .... **Platacanthomyidae**

b. Not as above 16

16a. Fossorial (resembling Geomyidae, but lacking external cheek pouches); limbs and claws short .... **Rhizomyidae**

b. Not as above 17

17a. Infraorbital foramen large, oval, not slitlike (fig. 15d); mandible weak (see glossary) .... **Zapodidae**

b. Infraorbital foramen a vertical slit (fig. 15e), or at least not large and oval; mandible strong 18

18a. Upper molar pattern prismatic (fig. 16a), cuspidate with two rows of cusps (fig. 16b), or laminate and separated by wide folds or valleys (fig. 16c) .... **Cricetidae**

b. Upper molar pattern never prismatic; if cuspidate, with three rows of cusps (fig. 16d) or chevron patterned (fig. 16e); if laminate, laminae not separated by wide folds or valleys but appressed closely together .... **Muridae**

19a. Infraorbital foramen smaller than foramen magnum; digits 5-5; fossorial .... **Bathyergidae**

b. Infraorbital foramen as large as or larger than foramen magnum 20

20a. Hind foot with 5 digits, webbed, except hallux free .... **Myocastoridae**

b. Not as above 21

21a. Greatly enlarged zygomatic arch containing a sinus .... **Dasyproctidae** (*Cuniculus*)

b. Zygomatic arch not greatly enlarged, no sinus 22

22a. Digits 4-3 23

b. Digits greater than 4-3 26

23a. Digits partly webbed; paroccipital processes extremely elongated .... **Hydrochoeridae**

b. Digits not webbed; paroccipital processes not extremely elongated 24

24a. Cheek tooth pattern of 2 or 3 tightly compressed transverse laminae .... **Chinchillidae** (*Lagostomus*)
b. Cheek tooth pattern not as above 25
25a. Cheek tooth pattern of two prisms connected by a single "bridge" of enamel and dentine; cheek tooth rows converge anteriorly .... **Caviidae**
b. Cheek tooth pattern of many tubercles, cross lophs, folds, or enamel islands, depending on age; cheek tooth rows not converging anteriorly .... **Dasyproctidae** (agoutis)
26a. Cheek teeth rooted, not evergrowing 27
b. Cheek teeth evergrowing 32
27a. Upper incisors with three grooves; 4 hind digits; no spines .... **Thryonomyidae**
b. Not with above combination of characters 28
28a. Digits 5-5, pollex may be rudimentary but nailed; some with weak spines 29
b. Digits less than 5-5 30
29a. Facial part of skull inflated by pneumatic cavities; no comb of stiff, bristle-like hairs over claws of hind feet .... **Hystricidae**
b. Facial part of skull not inflated; comb of stiff, bristlelike hairs over claws of hind feet .... **Echimyidae**
30a. Without bristlelike hairs or spines over claws of hind feet .... **Erethizontidae**
b. Comb of stiff, bristlelike hairs or spines protruding over claws of hind feet 31
31a. Occluded teeth will not allow antero-posterior jaw movement; cheek teeth with cusps; never spiny .... **Petromyidae**
b. Occluded teeth will allow antero-posterior jaw movement; cheek teeth with folds and lophs; sometimes spiny .... **Echimyidae**
32a. Without comblike hairs or spines over claws of hind feet 33
b. Comb of stiff hairs or spinelike hair protruding over claws of hind feet 35
33a. Digits 5-5 and well developed spines or quills .... **Hystricidae**
b. Digits less than 5-5; *or* without spines 34
34a. Digits 4-4; lower slopes and valleys of Andes, rare .... **Dinomyidae**
b. Digits more than 4-4; West Indies .... **Capromyidae**
35a. All molars with octodont (figure 8 pattern) or kidney-shaped crown pattern (fig. 16f) 36
b. Not as above 37
36a. Fossorial (resembling Geomyidae, but lacking external cheek pouches); total length greater than 220 mm .... **Ctenomyidae**
b. Not fossorial, more ratlike; *or* if fossorial, less than 220 mm total length .... **Octodontidae**
37a. Digits 4-4 .... **Chinchillidae**
b. Digits more than 4-4 38
38a. Upper cheek teeth only octodont; frontals constricted above orbits .... **Abrocomidae**
b. All cheek teeth with pattern of folds and lophs; frontals not constricted above orbits .... **Echimyidae**

Key to Families of Living Cetacea

1a. Teeth absent; baleen plates from roof of mouth; blowhole (external nostrils) of two slits; skull symmetrical (Mysticeti) 2
b. Teeth present; no baleen plates; blowhole single; skull non-symmetrical (Odontoceti) 4

2a. Head ¼ to ⅓ total length; no longitudinal furrows on throat; maxillae without nasal processes; long baleen plates; rostrum narrow and highly arched .... **Balaenidae**
b. Head less than ¼ total length; longitudinal furrows on throat; maxillae with nasal processes; short baleen plates; rostrum broad, or narrow and arched 3
3a. Dorsal fin present; 10-100 longitudinal furrows on throat; rostrum broad and flat; frontals barely, or not, exposed on vertex........ **Balaenopteridae**
b. Dorsal fin absent; 2-4 longitudinal furrows on throat; rostrum narrow with arched premaxillae; frontals broadly exposed on vertex........ **Eschrichtiidae**
4a. Beak extremely long and narrow; rami of lower jaw fused or closely appressed for most of length .... **Platanistidae**
b. Beak, if present, short, wide; rami of lower jaw not fused or closely appressed for most of length 5
5a. No beak; skull crested 6
b. Not with above combination of characters 7
6a. Zygomatic arch complete; indistinct dorsal fin .... **Physeteridae**
b. Zygomatic arch incomplete; distinct dorsal fin .... **Kogiidae**
7a. One or two large pairs of functional teeth in tip of lower jaw (other, smaller teeth may also be present); skull crested; dorsal fin present; tail flukes not notched in center .... **Ziphiidae**
b. Numerous homodont teeth in upper and/or lower jaws, *or* two functional teeth only in upper jaw tip; skull not crested; dorsal fin present or absent; tail notched in center 8
8a. Teeth reduced to 2 in upper jaw; no dorsal fin .... **Monodontidae** (*Monodon*)
b. Teeth numerous; dorsal fin present or absent 9
9a. Total teeth 32-40 and no dorsal fin; postnasal region of skull not elevated, skull flat dorsally .... **Monodontidae** (*Delphinapterus*)
b. Total teeth 6-200 or more and dorsal fin present; postnasal region of skull elevated, skull not flat dorsally .... **Delphinidae**

Key to Families of Living Carnivora

1a. Total teeth 30 or less; *or* if 32, cheek teeth small, weak and widely spaced.... 2
b. Total teeth 32 or more; *or* if 32, cheek teeth not small, weak and not widely spaced 4
2a. Cheek teeth weak and widely spaced .... **Hyaenidae** (*Proteles*)
b. Cheek teeth strong, not widely spaced 3

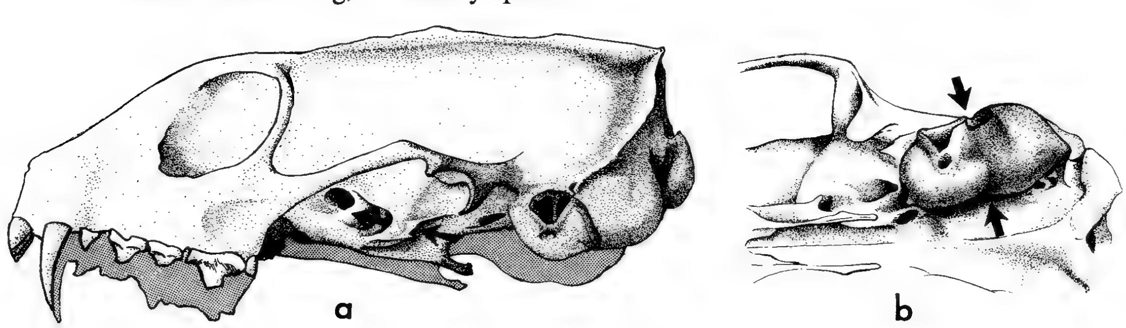


Figure 17. Alisphenoid canal, arrows, (a) and auditory bulla constriction, between arrows, (b) of *Mungus.*

3a. Digits 5-4; face short and flat, skull more globose; claws retractile (except *Acinonyx*) .... **Felidae**
b. Digits 5-5; face with longer rostrum, skull more rectangular; claws nonretractile .... **Mustelidae**
4a. Alisphenoid canal present (fig. 17a) 5
b. Alisphenoid canal absent 9
5a. Digits 5-5 6
b. Digits 5-4 or 4-4 8
6a. Auditory bulla constricted and divided by septum externally (fig. 17b); carnassials usually present .... **Viverridae**
b. Auditory bulla not as above; carnassials absent 7
7a. Head and body length less than 800 mm .... **Procyonidae** (*Ailurus*)
b. Head and body length greater than 800 mm .... **Ursidae**
8a. Total teeth 42 or more (except *Speothos* 38, *Cuon* 40); auditory bulla not constricted and divided by septum externally .... **Canidae**
b. Total teeth 40 or less (except *Rhynchogale* 42); auditory bulla constricted and divided by septum externally (fig. 17b) .... **Viverridae**
9a. Distinct black and white pattern, black ears and eye patches on white head; extremely broad, low cusped upper molars; carnassials absent .... **Procyonidae** (*Ailuropoda*)
b. Not as above 10
10a. Total teeth 32-34 11
b. Total teeth 36 or more 12
11a. Digits 5-5 .... **Mustelidae**
b. Digits less than 5-5 .... **Hyaenidae**
12a. Total teeth 40 (except *Potos* 36) .... **Procyonidae**
b. Total teeth 38 or less 13
13a. Auditory bulla constricted and divided by septum externally (fig. 17b) .... **Viverridae**
b. Not as above .... **Mustelidae**

Key to Families of Living Pinnipedia

1a. Well developed postorbital processes; small external pinna present; alsiphenoid canal present (fig. 17a) .... **Otariidae**
b. Postorbital processes vestigial or absent; no external pinna; alisphenoid canal absent (except Odobenidae) 2
2a. Upper canines modified as tusks, lower canines molariform; no lower incisors; can rotate hind limbs forward under body .... **Odobenidae**
b. No tusks, all canines similarly developed; 2 to 4 lower incisors; cannot rotate hind limbs forward .... **Phocidae**

Order Tubulidentata
Family **Orycteropodidae**

Order Proboscidea
Family **Elephantidae**

Order Hyracoidea
Family **Procaviidae**

Key to Families of Living Sirenia

1a. No upper incisors; nasal bones present; jugal bones not in contact with premaxillae; vestigial nails on flippers; tail "fin" rounded .... **Trichechidae**

b. One pair of upper incisors, tusklike in male, concealed in bone in female; nasal bones vestigial or absent; jugal bones in contact with premaxillae; no nails on flippers; tail "fin" deeply notched .... **Dugongidae**

Key to Families of Living Perissodactyla

1a. Total teeth 34 or less; incisors and canines, when present, vestigial; digits 4-3 or 3-3, enclosed by hooves; nasal bones enlarged, overhang premaxillae, usually rugose .... **Rhinocerotidae**

b. Total teeth 40 or more; incisors and canines strongly developed; digits 4-3 or 1-1; nasal bones not enlarged, not rugose 2

2a. Digits 4-3; nasal bones short, triangular, tapering and projecting freely anteriorly; nose and upper lip elongated as a short proboscis; cheek teeth with transverse ridges; open orbit .... **Tapiridae**

b. Digits 1-1; nasals not triangular; no proboscis; cheek teeth with flat surfaces and highly folded enamel loops; closed orbit .... **Equidae**

Key to Families of Living Artiodactyla

1a. Upper incisors present; molars bunodont (fig. 18a) or selenodont (Camelidae) (as in fig. 18b); no horns or antlers 2

b. Upper incisors absent; cheek teeth selenodont (fig. 18b); may have horns or antlers 5

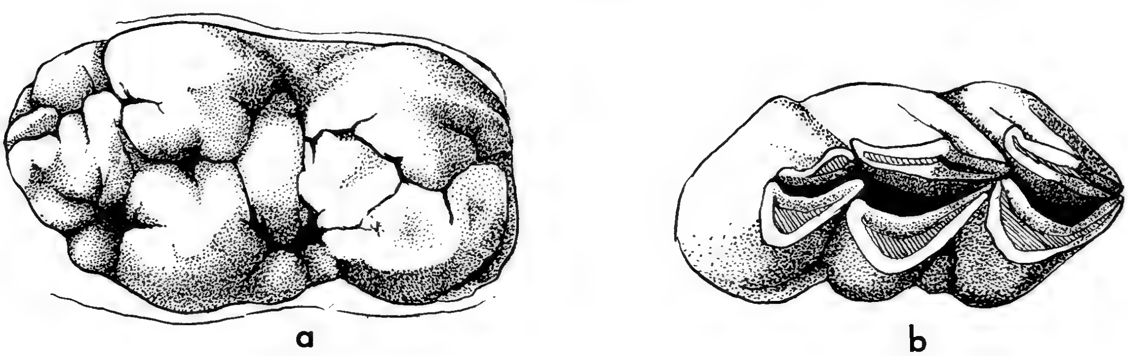


Figure 18. Crown patterns of bunodont, *Sus* (a), and selenodont, *Odocoileus* (b), molar teeth.

2a. Molars selenodont; digits 2-2 .... **Camelidae**

b. Molars bunodont; digits 4-4 or 4-3 3

3a. Skull very massive, orbits protected dorsally by protruding bone; canines enormous, evergrowing; nostrils anterodorsally placed .... **Hippopotamidae**

b. Skull not massive, orbits not protected dorsally by protruding bone; canines as tusks, frequently recurved; nostrils contained in flattened, terminal, cartilaginous pad (snout) 4

4a. Digits 4-3; incisors 2/3, total teeth 38 .... **Tayassuidae**

b. Digits 4-4; incisors 3/3, total teeth 44 (except *Babyrousa,* incisors 2/3, 34 total teeth; and *Phacochoerus,* incisors 1/3, 34 total teeth) (Tooth number is highly variable in suids, especially incisor number) .... **Suidae**

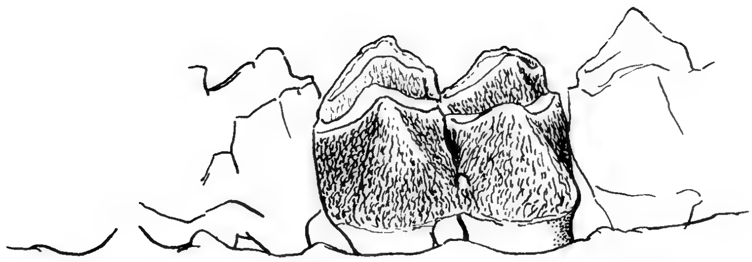


Figure 19. Rugose condition of enamel of *Giraffa* cheek tooth.

5a. Enamel of cheek teeth heavy, rugose (fig. 19); dew hooves (2nd and 5th digits) absent .... **Giraffidae**
b. Enamel of cheek teeth not heavy, not rugose; dew hooves present or absent.. 6
6a. Upper canines[1] present; antlers[1] present on some 7
b. Upper canines absent; horns[1] or antlers[1] on most 8
7a. Digits 4-4, of subequal development; no lacrimal fossa; no, or very small, facial vacuity (fig. 20); no antlers; orifice of lacrimal canal (fig. 20) single, or, if double, one opening much the larger .... **Tragulidae**
b. Digits 4-4, 2nd and 5th greatly reduced; lacrimal fossa present; facial vacuity present (fig. 20a); antlers on some; orfice of lacrimal canal double (fig. 20a) .... **Cervidae**

[1]Some females lack these characters .

EITHER

8a. Dew hooves present; horns or antlers present 9
b. Dew hooves absent; horns present.... 10
9a. With antlers; facial vacuity present (may be obscured in large, old specimens) (fig. 20a); orifice of lacrimal canal double (fig. 20a) .... **Cervidae**
b. With horns; facial vacuity reduced or absent (some exceptions) (fig. 20b); orifice of lacrimal canal usually single (fig. 20b) .... **Bovidae**
10a. Deciduous horn with bony core; facial vacuity present (as in fig. 20a) .... **Antilocapridae**
b. Non-deciduous horn with bony core; facial vacuity reduced or absent (some exceptions) (fig. 20b) ..**Bovidae**

OR

8a. Deciduous horn with bony core; dew hooves absent; facial vacuity present (as in fig. 20a) .... **Antilocapridae**
b. Not with above combination of characters 9
9a. With antlers; facial vacuity present (may be obscured in large, old specimens) (fig. 20a); orifice of lacrimal canal double (fig. 20a) .... **Cervidae**
b. With non-deciduous horns; facial vacuity reduced or absent (some exceptions) (fig. 20b); orifice of lacrimal canal usually single (fig. 20b) .... **Bovidae**

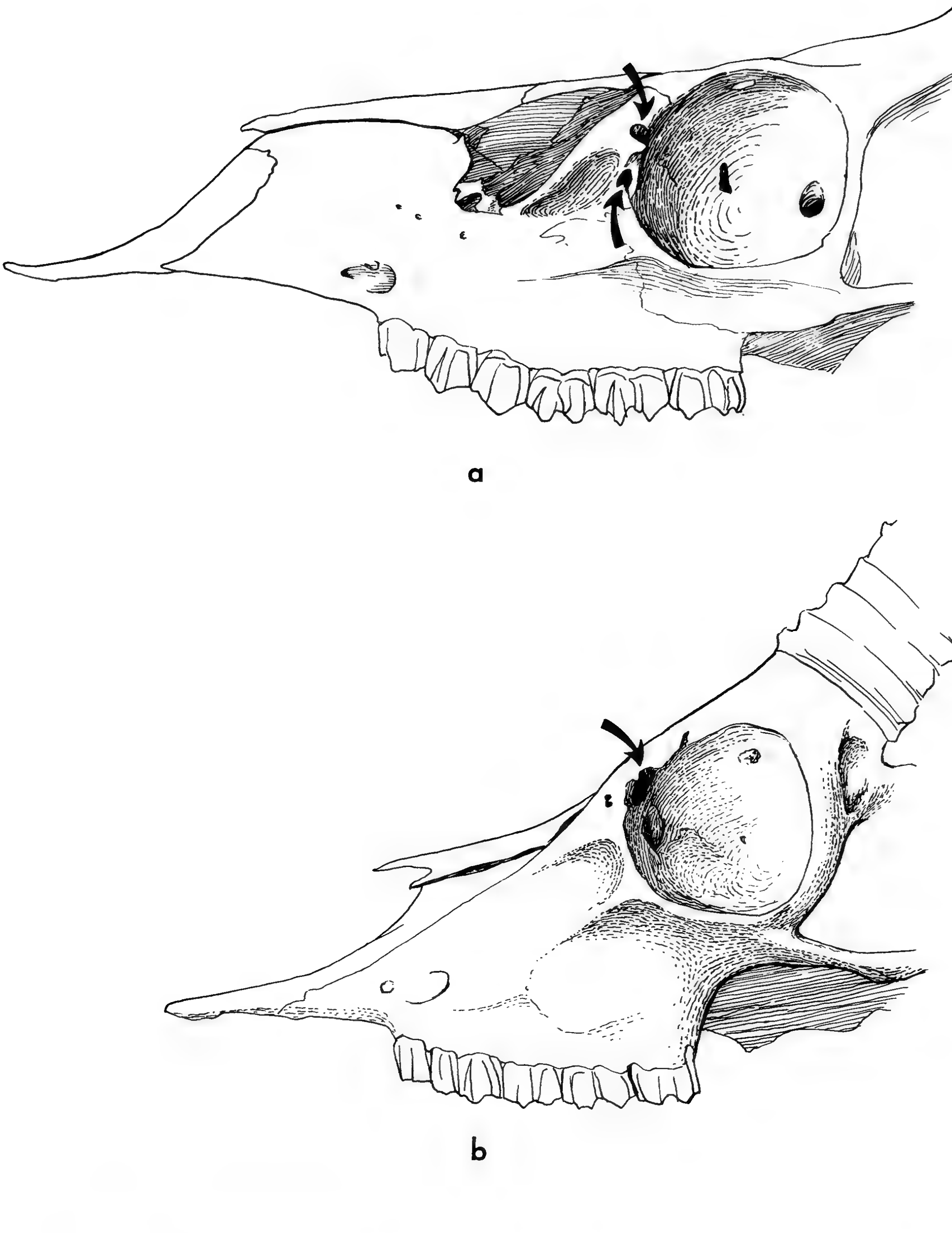


Figure 20. Double lacrimal canal orifice (two arrows) and facial vacuity (lined area anterior from upper arrow) of *Odocoileus* (a) and single lacrimal canal orifice (single arrow) and absence of facial vacuity of *Gazella* (b).

Alisphenoid bone—bone in the posteromedial portion of the orbit containing the last three of a series of four large foramina.
Alisphenoid canal—opening partly connecting the two posteriormost foramina of the alisphenoid bone (fig. 17a).
Alveolus—tooth socket.
Angle of jaw—the most posterior, ventral projection of the ramus. In marsupials, this is inflected, that is, curved, usually medially (fig. 1).
Antitragus—fleshy, cartilaginous protrusion of the pinna at the back (posterior) of the ear opening. Small in most mammals.
Auditory bulla—enlargement of bones located below external ear openings in posterior half of skull. Varied in development.
Basioccipital—bone in ventral part of skull bounded posteriorly by foramen magnum and laterally by the auditory bulla complex.
Beak—clearly distinguishable anterior elongation of rostrum of some whales.
Bilophodont—two distinct ridges along the functional surface of a tooth formed by enamel connnection between two cusps (fig. 12).
Bony palate—portion of roof of mouth composed of bone. In skull, bounded by alveoli and internal nares.
Bony skin—skin which has ossified and is as hard as other skeletal parts, for example, armadillos.
Brow ridges—prominent ridges of the frontal bone located above the eye sockets.
Canine tooth—an enlarged (usually) tooth anterior to the premolars. The most anterior tooth (when present) of the maxillary bone in the upper jaw. On dentary bones of lower jaw, immediately anterior to upper canine when jaw closed. Single-rooted and single-cusped usually.
Caniniform—resembling a canine tooth.
Carnassial teeth—last upper premolar and first lower molar of most carnivores which act to shear (like a pair of scissors) when occluding, rather than crush when the surfaces meet.
Cheek teeth—the premolars and molars.
Chevron pattern—pattern on the functional surface of a tooth characterized by a series of V-shaped enamel ridges (fig. 16e).
Claw—a sharp, horny projection from the tip of a digit. Resembles a folded, sharpened nail.
Cochlea—part of inner ear. Somewhat coiled bone which is part of bony auditory complex.
Comb—series of stiffened hairs projecting over claws of some rodents.
Cranium—the skull, not including the lower jaw.
Cuspidate—pattern on the functional surface of a tooth consisting of pointed or rounded enamel elevations. May be worn at least partly to the dentine in older individuals (fig. 16b, d, e).
Dental formula—method of designating the number and location of teeth in a heterodont dentition, or location in a homodont dentition. I 3/3, C 1/1, P 4/4, M 3/3 = 44 means that there are three upper and three lower incisors, etc., on each side of the mouth, therefore, a total of 44 teeth in the mouth.
Dentary bone—one of the two bones composing the lower jaw.
Dentine—bonelike material under the enamel and forming the major part of a tooth. May be exposed in certain types of teeth such as those of rodents, resulting in surface patterns of dentinal lakes surrounded by the harder enamel.
Dew claw—elevated termination of reduced digits in some carnivores and others. Normally does not touch ground when walking.
Dew hoof—as preceding except digit terminates as a hoof. Found in many artiodactyls.
Diastema—a distinct space between teeth in a heterodont dentition where a tooth or teeth are not normally present, particularly the canine. Used mostly with regard to lagomorphs, rodents, and sirenians.
Digit—finger or toe.
Digital formula—method whereby the number and arrangement of fingers and toes on each limb is designated. Digits are numbered medial to lateral from 1 to 5 with digit 1 being the pollex (or hallux). A mammal with a digital formula of 5-4 has five digits on each

fore foot, four on each hind foot. In some rodents, especially on the fore foot, a nail may be present even though the digit is essentially missing and nonfunctional. This is not counted as a digit in the digital formula.

Enamel—smooth, hard outer coating of the teeth of most mammals.

External auditory canal — bony extension of auditory bulla containing the external auditory meatus at its termination (fig. 11b).

External auditory meatus — opening of auditory bulla on the outside surface of the skull.

Face —anterior portion of the skull, approximately from and including the orbits forward.

Facial vacuity —opening on the face of skull bounded by the frontal, lacrimal, maxillary, and nasal bones in some artiodactyls. Prevents articulation of the lacrimal and nasal bones (fig. 20a).

Flipper —a broad, flattened limb modified for the posterior part of the body of whales resulting in tail "fin."

Flukes —horizonta (lateral) projections of swimming.

Foramen magnum —opening in basal or posterior portion of skull through which the spinal cord exits.

Fossorial—adapted to underground life. Characterized by reduction of eyes and pinnae, soft silky fur, enlarged feet for digging, short tail, and a sausage-shaped body.

Frontal bone —one of the bones forming the forehead, brow ridges, and roof of the orbit.

Glenoid fossa—concavity for articulation of the dentary bone.

Hallux —first digit of hind limb. Big toe.

Heterodont —dentition in which the teeth are of several kinds, not essentially identical in form and function.

Homodont—dentition in which the teeth are of a single kind, usually about the same size, and are essentially identical in form and function.

Hoof—a heavy, horny covering over the external surface of the tip of a digit. Varied in development.

Imbricate —overlapping.

Incisiform—resembling an incisor tooth.

Incisor tooth —one of the anteriormost teeth in the upper and lower jaws; located on the premaxillary bone in the upper jaw. Single-rooted and occasionally bifid or trifid. Variously adapted for scraping, snipping, holding, etc.

Infraorbital foramen —opening on side of rostrum or below zygomatic plate or arch (fig. 15).

Interfemoral membrane—webbing of skin extending between hind legs of bats and including all or much of the tail (if present) (fig. 7).

Jugal —central bone of the zygomatic arch articulating anteriorly with the maxillary bone.

Keeled —characterized by having a raised strip along the center (usually) of the structure described.

Lacrimal bone —one of the bones usually articulating with the posterior portion of the nasal bone and forming part of the anterior and medial wall of the orbit.

Lacrimal canal —opening on the lateral edge of the orbit within the lacrimal bone (fig. 20).

Lacrimal fossa —depression in the lacrimal bone in some artiodactyls.

Laminate —pattern on the functional surface of a tooth consisting of a series of thin plates. A tooth composed of a series of thin plates (fig. 16c).

Lobate—having two (or more) rounded parts.

Mandible—lower jaw. In rodents, may be considered strong (heavy bone, bold outline, not flaring medially) or weak (weaker bone, flaring medially with resultant lessening of the bold lateral outline).

Maxilla (maxillary bone)—one of the bones forming most of the upper jaw. Contains the upper cheek teeth and canines. Process may form anterior portion of the zygomatic arch.

Molariform—resembling a molar tooth.

Molar tooth —a three- or four-rooted tooth in the posterior portion of the jaws mostly adapted for crushing foods.

Nail—a thin, horny plate on the upper side of the tip of a digit.

Nasal bone—one of the two small bones forming the bridge of the nose.

Nasal septum—cartilaginous separation of the two external nares (nostrils).
Nose leaf—fleshy, cartilaginous structure extending dorsally from the tip of the nose of some bats. Variable in development. Difficult to discern on dry specimens if leaf small.
Occlusion—closing of tooth rows to the point where upper and lower teeth touch one another.
Orbit—eye socket. A closed orbit results when zygomatic and frontal postorbital processes meet and enclose eye posteriorly with bony ring; otherwise orbit is open.
Orbital fossa—depression on the frontal bone (mostly) where eye is located. Mostly anterior to the postorbital processes. Usually confluent with temporal fossa but may be completely separated by bone in some forms, for example, higher primates.
Palatine bone—one of the bones forming the major part of the hard palate (roof of mouth).
Paroccipital process—extension of the occipital bone over the posterior portion of the auditory bulla.
Patagium—membrane or web of skin making up the wings of bats. Also the folds of skin between the tail, legs, and neck of some squirrels, marsupials, and the flying lemurs.
Phalanx (plural, phalanges)—individual bone making up sections of digits.
Pinna—cartilaginous protrusion about the external auditory meatus. "Ear."
Pollex—first digit of fore limb. Thumb.
Postorbital process—bony projection from the frontal bone marking the posterior edge of the orbital fossa and anterior edge of the temporal fossa. (May also refer to projection from the jugal, but usually not so used in these keys.) Posterior to the eye.
Premaxilla (premaxillary bone)—one of the paired bones forming the anteriormost portion of the upper jaw. Contains the upper incisor teeth.
Premaxillary gap—space between extreme anterior parts of the maxillae or premaxillae because of the lack of the palatal branches of the premaxillae or the entire premaxillae (fig. 8a).
Premolariform—resembling a premolar tooth.
Premolar tooth—a two- or three-rooted tooth anterior to the molars and posterior to the canines. Variously adapted for crushing, sectioning, etc.
Prismatic—pattern on the functional surface of a tooth characterized by triangular and other shapes formed by enamel surrounding dentinal lakes and resulting in a flat surface for grinding (fig. 16a).
Proboscis—fleshy extension of the nose and upper lip of elephants (trunk) and tapirs.
Procumbent—exaggerated condition of incisor teeth in which they may extend straight forward (fig. 4).
Quill—an extremely stiff, large, sharp-pointed outgrowth of the skin (probably modified hairs). Heavier than a spine.
Ramus—either half of the lower jaw, separated anteroposteriorly.
Rostrum—portion of the skull anterior to the orbits.
Rugose—corrugated pattern in enamel of major portion of a tooth (fig. 19).
Saltatorial—hopping type of locomotion. Characterized by enlarged hind limbs and feet and frequently with an elongated tail, for example, kangaroo, jackrabbit, etc.
Scale—a thin, hard, flat plate of material covering part of the skin. Developed to varying degrees.
Sinus—hollowed out medial area of the zygomatic arch. Or, cavities within certain bones.
Skull—the entire bony structure making up the head of a mammal, including the lower jaw.
Spine—a stiff, sharp-pointed, modified hair. Lighter than a quill.
Syndactyly—condition of digits where bones of at least two digits are enclosed within a common, fleshy sheath. In marsupials, the second and third digits of the hind foot are frequently so united resulting in a digit that appears double-clawed (fig. 3b).
Temporal fossa—depression on the temporal (squamosal) bone (mostly) posterior to the postorbital processes. Usually confluent with orbital fossa but may be completely separated by bone in some forms, for example, higher primates.
Tragus—fleshy, cartilaginous protrusion of the pinna at the front of the ear opening. Usually much enlarged in bats (fig. 5b).

Transverse plate —one of the series of large, heavy, flattened parts which make up the cheek tooth of an elephant (fig. 2).

Vacuity, facial—see facial vacuity.

Vestigial —refers to a structure greatly reduced in size from the usual in the taxon under consideration.

Zygomatic arch —portion of the skull composed of the jugal and parts of the maxillary and squamosal bones. Cheek "bone."

Zygomatic plate—anterior, flattened maxillary portion of the zygomatic arch of some mammals, for example, rodents.

SELECTED REFERENCES

The literature on mammals of the world is voluminous and encompasses popular accounts, field guides, and many kinds of technical papers and reports. The following ten references are included here as source books, not only of information, but, since most have bibliographic sections, as guides to additional literature.

ANDERSON, S., AND J. K. JONES, JR. (eds.). 1967. Recent mammals of the world. A synopsis of families. Ronald Press Co., New York. 453 p.

BOURLIÈRE, F. 1955. Mammals of the world, their life and habits. Alfred A. Knopf, Inc., New York. 223 p.

BOURLIÈRE, F. 1964. The natural history of mammals. 3rd ed. Alfred A. Knopf, Inc., New York. 387 p.

COCKRUM, E. L. 1962a. Introduction to mammalogy. Ronald Press Co., New York. 455 p.

COCKRUM, E. L. 1962b. Laboratory and field manual for Introduction to Mammalogy. 2nd ed. Ronald Press Co., New York. 116 p.

DAVIS, D. E., AND F. B. GOLLEY. 1963. Principles in mammalogy. Reinhold Publ. Corp., New York. 335 p.

GRASSÉ, P.-P. (ed.). 1955, 1967-68. Traité de Zoologie. vols. 16, 17. Mammifères. Masson et Cie., Paris.

SANDERSON, I. T. 1955. Living mammals of the world. Hanover House, Garden City, New York. 303 p.

SIMPSON, G. G. 1945. The principles of classification and a classification of mammals. Bulletin, American Museum of Natural History, New York. vol. 85, 350 p.

WALKER, E. P., *et al.* 1968. Mammals of the world. 2nd ed. J. L. PARADISO, ed. Johns Hopkins Press, Baltimore, Maryland. 2 vols., 1500 p.

Grant Dahlstrom / The Castle Press